(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 116 596**
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **22.11.90**

(51) Int. Cl.[5]: **A 61 M 5/00**

(21) Application number: **83902678.8**

(22) Date of filing: **09.08.83**

(86) International application number:
PCT/US83/01216

(87) International publication number:
WO 84/00691 01.03.84 Gazette 84/06

(54) **LINEAR PERISTALTIC PUMPING APPARATUS AND DISPOSABLE CASETTE THEREFOR.**

(30) Priority: **12.08.82 US 407440**

(43) Date of publication of application:
29.08.84 Bulletin 84/35

(45) Publication of the grant of the patent:
22.11.90 Bulletin 90/47

(84) Designated Contracting States:
BE DE FR GB NL

(56) References cited:
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FR-A-2 475 646
GB-A-2 012 373
US-A-2 483 924
US-A-3 582 234
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EP 0 116 596 B1

Courier Press, Leamington Spa, England.

Description

Background

Peristaltic pumps of the type known for use for the infusion of medical fluids, or for the removal of body fluids, are generally characterized by a length of flexible tubing which is disposed within an arc between a stator-like member and a rotor assembly. The rotor assembly is provided with a plurality of rollers which, upon rotation of the rotor assembly, successively pinch-off the tube and advance the location of the pinch-off so as to progressively advance the fluid within the tube at a rate determined by the rate of rotation of the rotor. Such pumps have the advantages of having a disposable element in the fluid flow path, in that the length of tubing in the pump may be replaced after each use, and cassettes have been provided to facilitate the insertion and removal of such lengths of tubing. Patents illustrative of such constructions are US-A-3,927,955; US-A-4,256,437; and US-A-4,187,057. Despite their advantages, such systems are also known to exhibit poor accuracy and reproducibility, require substantial power for operation (thereby making them relatively expensive and inappropriate for battery operation), be relatively complex and bulky in construction, and require a cassette which, because it must support the tube along an arcuate path, is relatively elaborate, complex, and expensive.

Patents US-A-4,199,307 and US-A-4,273,121 disclose linear cassettes for medical infusion systems, the cassettes comprising tubes having flexible portions which are engaged by movable bar members at three different locations to control flow of fluid through the tubes. The use of pressure bars is also disclosed in US-A-3,083,647.

Other patents such as US-A-3,229,643; US-A-3,981,633; and US-A-3,233,553 disclose pumps in which shafts and eccentrics are disposed internally rather than externally in relation to the flexible tubes. Other patents generally illustrative of the state of the art are US-A-3,067,692; US-A-2,722,893; US-A-1,874,667; US-A-2,414,355; and US-A-2,249,806.

Patent Specification DE-A-2453296 describes a pump arrangement for medical purposes which includes a platen 9 that holds a tube 8 in contact with a membrane 7 in turn engaged by a transport screw 5. The platen is part of the cassette, not part of the pump housing, and has a channel for receiving the tube 8. It has no planar, perimetric frame defining an opening and a straight section of elastomeric tubing extending across said opening.

This invention provides a linear peristaltic pump apparatus comprising a housing; a shaft rotatably supported by said housing; means for rotating said shaft; a helix defining a first linear zone of contact; a cassette removably supported by said housing and comprising a rigid frame and a generally straight section of elastomeric tubing supported thereby; means provided by said housing for orienting said frame with said section of tubing laying in the same plane as said first zone of contact; and platen means engageable with said section of elastomeric tubing to urge the same into engagement with the opposite side of said first linear zone along a second linear zone of contact parallel with said first zone of contact; characterized by a series of bearing assemblies each having concentric inner and outer bearing members; said inner members being eccentrically mounted upon said shaft with the centers of said inner members being arranged to describe a helix about the axis of said shaft; an elastomeric membrane extending along and tangentially engaging the outer members of said bearing assemblies along the first linear zone of contact; said frame of said cassette being planar and perimetric, and defining an opening; attachment sleeves; provided by said frame along opposite edges of said opening; said straight section of elastomeric tubing extending across said opening and having end portions secured to said attachment sleeves; said platen means being provided by said housing and extending into said opening to urge said tubing section against said membrane towards said bearing assemblies when said apparatus is in operation.

This invention also provides a disposable cassette for use in a linear peristaltic pumping apparatus, comprising a rigid planar frame; characterized by said frame being perimetric and extending about an opening; attachment sleeves provided by said frame on opposite edges of said opening; and a straight section of elastomeric tubing extending across said opening and having end portions secured to said attachment sleeves.

The cassette has the advantages of being relatively inexpensive in constructing, and is easily and quickly inserted and removed from the pump housing. In the operation of the pump, the tensioned section of tubing that spans the opening of the cassette frame is interposed between a platen and an elastomeric membrane, both of which are provided by the pump housing. The elastomeric membrane engages the outer members or races of a series of bearing assemblies eccentrically mounted upon a power-driven shaft, the membrane engaging the bearing assemblies along a first band or linear zone of contact lying in the same plane as the rotational axis of the shaft. The elastomeric tubing of the cassette engages the opposite side of the membrane along a second band or linear zone of contact lying in the same plane and parallel with the first line of contact. Replacement of a cassette may be achieved simply by withdrawing the platen, which may be carried by a door of the housing assembly, and withdrawing the cassette and its elastomeric tubing from contact with the membrane that overlies the bearing assemblies.

In a preferred embodiment particularly suitable for the administration of parenteral fluids, the cassette takes the form of a generally rectangular perimetric frame having an elongated rectangular opening. Attachment sleeves face each other from opposite edges of that opening, and the

section of tensioned elastomeric tubing has its ends secured to the attachment sleeves so that the tubing section bridges the full length of the opening. The cassette may include other tubing sections secured to and communicating with the attachment sleeves, the other sections being provided at their free ends with suitable coupling elements for connecting the cassette to a patient and a source of parenteral fluid.

Other features, advantages, and objects of the invention will become apparent from the specification and drawings.

Drawings

Figure 1 is a perspective view of a system utilizing the peristaltic fluid-pumping apparatus of the invention for metered intravenous (IV) administration.

Figure 2 is a side elevation taken partly in section showing the pump apparatus.

Figure 3 is an enlarged vertical sectional view showing details of the apparatus.

Figure 4 is a still further enlarged horizontal sectional view taken along line 4—4 of Figure 3 and showing the eccentric bearing assembly in an extreme position compressing and occluding the elastomeric tube.

Figure 5 is a horizontal sectional view similar to Figure 4 but showing the bearing assembly in its outer extreme position with the elastomeric tube nearly fully expanded.

Figures 6—9 are schematic views showing the sequence of operation of a modified fluid-pumping apparatus.

Figure 10 is a fragmentary perspective view of the apparatus modified to include a membrane preferentially reinforced against stretching in directions transverse to the axis of the tube.

Figure 11 is a fragmentary perspective view of a pump apparatus modified to utilize a replaceable cassette for supporting the fluid delivery tube.

Figure 12 is a perspective view showing the opposite side of the cassette depicted in Figure 11.

Figure 13 is an enlarged cross sectional view taken along line 13—13 of Figure 12.

Figure 14 is an enlarged sectional view along line 14—14 of Figure 12.

Figure 15 is an enlarged longitudinal sectional view along line 15—15 of Figure 12.

Detailed Description

Referring to the drawings, and particularly to Figures 1—9, the numeral 10 generally designates an apparatus including a metering pump 11, a fluid delivery tube 12, coupling means 13 for coupling one end of the tube to a suitable container 14, in this case a parenteral solution container supported by a conventional IV stand 15. The coupling means takes the form of a spike 13a formed as part of drip chamber housing 13b and received within the opening of a vent-providing stopper at the mouth of the container. A suitable valve or clamp 16 may be provided for controlling or interrupting the flow of fluid through tube 12.

The opposite end of the tube 12 leads to a suitable connector 17 represented diagrammatically in Figures 1 and 2. In the case of a fluid administration system, the connector would ordinarily take the form of a hypodermic needle or cannula. Excluding metering pump 11, the elements of the system shown in Figures 1—2 are conventional and well known and, therefore, further discussion of such elements is believed unnecessary herein.

The metering pump 11 includes a housing 18 equipped with a handle 19 and a door or removable panel 20. Attachment of the housing to IV stand 15 is achieved by thumb screw 21 which can be tightened against the pole of the stand when the pole extends between a pair of ears 22, 23 projecting from the rear of the housing. An electric stepping motor 24 drives the pump and a power pack 25 composed of one or more batteries or power cells (5 are shown) is located within the housing to supply power for the motor and other components. The electrical controls for the operation of the motor may be simple or complex depending on the requirements and use of the system. In the illustration given, a plurality of finger buttons 26 are provided at the face of the housing and a digital display window 27 reveals information concerning selected delivery rates as controlled by motor speed for a tube 12 of selected cross sectional dimensions.

The pump mechanism 28 includes a series of bearing assemblies 29 each having inner and outer bearing members 30 and 31, respectively. Preferably the inner member 30 takes the form of an inner bearing race, the outer member 31 constitutes an outer race, and anti-friction bearing elements 32 are disposed therebetween. Such anti-friction bearing elements would normally consist of ball bearings; however, the use of various types of roller bearings is possible. Futhermore, other types of bearing assemblies, such as self-lubricating sleeve bearings, might be advantageously used.

Each inner race (or member) is mounted eccentrically upon a drive shaft 33. Journalling means in the form of hangers 34 and bearings 35 (preferably ball bearings) support the ends of drive shaft 33 as shown in Figures 2 and 3. One end of the shaft (the lower end in the embodiment illustrated) is operatively connected to motor 24. A flexible coupling 36 is shown for that purpose, but other connecting means may be used. Also, while the drive shaft 33 is illustrated with its longitudinal axis oriented vertically, it is to be understood that the action of the pump is independent of such orientation as long as fluid is available to the pump through line or tube 12.

Each inner race (or member) 30 is eccentrically mounted upon shaft 33 with the centers of all such races being equidistant from the axis w of the drive shaft and with the angular spacing between all of such centers being essentially the same and the sum of the angular spacing being 360 degrees. Where a series of seven bearing assemblies is provided as shown, the incremental

angular distance between the centers of the inner races should be 360 degrees divided by seven, or approximately 51.43 degrees. A greater or smaller number of bearing assemblies may be provided, although the preferred range is believed to be 3 to 30 such assemblies. Of particular importance is the fact that the series of bearing assemblies must be mounted upon the drive shaft 33 so that the centers x of the inner races describe a spiral or helix of at 360 degrees about drive shaft axis w.

The inner races 30 may be secured upon the shaft 33 in any suitable manner. In the embodiment illustrated in the drawings, shaft 33 has a central portion of non-circular (heptagonal) cross-sectional outline and the eccentrically-disposed openings 30a in the respective inner races 30 are of the same configuration so that the eccentric bearings may be incrementally positioned upon the shaft with their centers helically oriented. The inner races are thereby secured against independent relative rotation with respect to shaft 33, and locking elements 38 are secured to the shaft at opposite ends of the series of bearing assemblies 29 to hold the series against axial displacement.

The central portion of elastomeric tube 12 is supported with its longitudinal axis parallel with the rotational axis of the shaft 33 and with a linear zone of the outer surface of a membrane 40 in contact with the outer surfaces of outer races 31. Ideally, the tube is stretched so that it is under slight axial tension, thereby assuring that the portion of the tube opposite the bearing assemblies will be straight or linear in the absence of lateral distorting forces. For purposes of such tensioning, and to insure parallel alignment of the tube with the axis w of the drive shaft, mounting straps or brackets may be located at 39 to immobilize those portions of the tube with respect to housing 18. Alternatively, such portions of the tube may be secured to the housing by adhesives or by any other suitable means.

The elastomeric imperforate membrane 40 is interposed between tube 12 and the cylindrical surfaces of outer bearing members or races 31, as shown most clearly in Figures 3—5. The membrane is planar in an untensioned state and assumes the configuration shown in Figure 3 because of the distortions developed by bearing assemblies 29 and tubing 12. It bridges the space in which the series of bearing assemblies is located and separates that mechanism from tube 12. Any suitable means may be used to secure the periphery of the membrane to casing or housing 18; in the embodiment illustrated, a frame 41 is secured to the housing by screws 42 and clamps the perimeter of the membrane tightly in place.

A rigid platen 43 braces tube 12 and not only maintains the tube in contact with one surface of the membrane 40 but also maintains the opposite surface of the membrane in contact with the outer races of the bearing assemblies 29. More specifically, as shown in Figures 4 and 5, the outer races tangentially engage the membrane 40 along a first linear zone or band of contact y, and the elastomeric tube engages the opposite side of the membrane along a second linear zone or band of contact z directly behind or opposite from the first band of contact. Also, the two bands of contact y and z lie in the same plane as the rotational axis w of drive shaft 33.

Each bearing assembly 29 has its inner race 30 eccentrically mounted so that its center x moves between one extreme position in which center x is spaced maximally from the platen and the lumen 12a of the tube is substantially fully open (Figure 5) and the other extreme position in which center x is spaced minimally from platen 43 and the lumen of the tube is closed (Figure 4). To reduce torque peaks that develop as each bearing assembly sweeps through the tube-occluding position of Figure 4, especially when two such assemblies (the first and last of the series) simultaneously compress and substantially close the tube, platen 43 may be provided with a resilient facing 44 engaging and supporting tube 12. The facing must not be so compliant that it will allow outward displacement of the tube in preference to complete occlusion of that tube. The tube should close as shown in Figure 4 with the resilience of facing 40 serving the primary purpose of reducing the torque peak once such occlusion has taken place. Additionally, the resilient facing may perform the secondary function of providing additional resistance to lateral or transverse displacement of the portion of the tube 12 extending alongside the series of bearing assemblies 29 and membrane 40. In general, a facing material having a durometer of about 60 to 80 has been found effective.

Lateral displacement of the tube during pump operation is prevented primarily by membrane 40 and by the effectiveness of anti-friction bearing elements 32. A slight frictional resistance is necessarily inherent in the operation of each bearing assembly 29, but that resistance is substantially less than the frictional resistance between the outer surface of outer race 31 and the surface of membrane 40 in contact therewith. Tangential sliding movement between the outer races of the bearing assemblies and membrane 40 is therefore avoided. Since the membrane's resistance to stretching is substantial in relation to the frictional resistance inherent in the operation of the bearing assembly, rotational forces that might otherwise be transmitted to tube 12 are isolated by membrane 40.

In the form of the invention depicted in Figures 2—5, each outer race 31 remains in continuous contact with membrane 40 even when the center x of bearing assembly 29 is spaced maximally from the platen and the lumen of tube 12 is substantially fully open (Figure 5). Alternatively, the apparatus may be adjusted or constructed so that it is structurally and functionally identical to what has already been described except that the outer race of each bearing assembly is momentarily drawn out of contact with the membrane when the shaft has rotated to space center x its maximum distance from the platen, in which case the outer race will be free to rotate a limited

angular distance (i.e., 360 degrees divided by the number of assemblies) until it is again brought into contact with the membrane. Such an embodiment not only provides the advantages of allowing the tube to expand to a fully open position (in which the cross section of the lumen is circular in outline) but also, by permitting incremental rotation of the outer race, tends to produce more uniform bearing wear and thereby increase the operating life of the apparatus.

The operation of such a modified version of the pump is schematically illustrated in Figures 6—9. The two concentric circles represent a bearing assembly 29 with the inner circle indicating the inner race or member 30 and the outer circle representing the outer race or member 31. The inner race is eccentrically mounted with the extent of eccentricity being the distance between the center x of the inner race and the rotational axis w of the mounting shaft.

The linear zone or band of contact z between tube 12 and membrane 40 is clearly shown in Figures 6—9. Similarly, the linear zone or band of contact y between the membrane and the outer race is revealed in Figures 6—8; however, when the inner race of the bearing assembly has rotated into a position where its center x approaches maximum spacing from platen 43, a gap or spacing 45 develops between outer race 31 and membrane 40 (Figure 9). The gap assures that tubing 12 will not be restrained by the bearing assembly from assuming a condition of maximum lumen cross sectional area, and also allows incremental angular advancement of the outer race 31.

The incremental angular advancement may be observed by noting the relative positions of reference points P_1 and P_2 along the outer and inner races. In Figure 6, such points are shown to be in radial alignment. As the drive shaft rotates 90 degrees about axis w, reference point P_2 has shifted 90 degrees in a counterclockwise direction while P_1 retains its original position because rotation of the outer race is resisted by contact with membrane 40. In Figure 8, points P_1 and P_2 are 180 degrees apart with P_1 still remaining in its original position. However, as the inner race rotates from the position depicted in Figure 8 towards the position of Figure 9, the outer race 31 moves out of contact with membrane 40 and the slight frictional resistance inherent in the operation of assembly 29 causes outer race 31 to rotate along with inner race 30. Point P_1 therefore shifts a limited angular distance from its original position and will continue such movement until the outer race again contacts membrane 40 in approaching the position of Figure 6. When the Figure 6 position is again assumed, however, reference points P_1 and P_2 will no longer be in radial alignment but will be separated a limited angular distance from each other.

Figure 10 illustrates a construction which is identical to those already described except that membrane 40' has a multiplicity of flexible but non-stretchable reinforcing elements 45 extending along the plane of the membrane in a direction perpendicular to bands of contact y and z. The embedded filaments may be formed of Dacron, wire, or any other suitable material, and prevent lateral stretching of the membrane without appreciably affecting expansion and contraction of the membrane in the general direction of the lines of contact. The preferential reinforcement of the membrane insures that frictional resistance inherent in the construction of bearing assemblies will not in any case be transmitted through the membrane to cause lateral displacement of tube 12 and possible variation in the delivery rate of the pump apparatus. Such reinforcement, while generally unnecessary, may become important in pumps of larger capacity in which the tubing is relatively large (e.g., more than 1 cm. OD) and of substantial wall thickness.

In the operation of the embodiments of Figures 1—10, rotation of shaft 33 causes a progressive occlusion of the tube 12 in a downward direction as each bearing assembly in downward sequence assumes the tube-collapsing position depicted in Figure 4. (It will be understood that if the direction of shaft rotation were reversed, the progressive action of the bearing assemblies would similarly be reversed to drive a segment of fluid upwardly rather than downwardly.) Figure 3 shows the uppermost bearing assembly of the series in the tube-occluding position of Figure 4. The next tube bearing assembly directly below it is advancing into occluding positions, the middle assembly is in its maximally open position of Figure 5, and the remaining three bearing assemblies therebelow are progressing towards their maximally open positions. A metered segment of fluid is thereby forced downwardly through the tube in the direction of peristaltic action.

Figures 11—15 depict a preferred embodiment of the invention similar to the embodiments already described except that tube 112 is part of a replaceable cassette 100. If the apparatus is to be used for the administration of parenteral fluids, then the cassette may include a suitable coupling 113 at one end of the tube, the coupling being equipped with a spike and drip chamber as previously indicated and the upper portion of the tube also being equipped (if desired) with a control device 116 similar to device 16. The opposite end of the tube is provided with a suitable connector 117 which, if the apparatus is to be used for parenteral administration, would take the form of a needle or cannula.

The mid-portion of tube 112 is stretched slightly across the opening 150 of a rigid perimetric frame 151. The frame is generally planar and may be provided with inner and outer flanges 152 and 153 for increased rigidity. To facilitate mounting the tube 112 upon the frame 151, the tube may be formed in sections, with mid-section 112a having its ends secured to rigid mounting sleeves 154 and 155. The sleeves are provided with wing portions 156 that are permanently secured by heat sealing, fusion bonding, or any other suitable means to the portions of frame 151 above

and below window opening 150. The upper section 112b of the elastomeric tubing has its lower end secured to the rigid sleeve 154, and the lower section of the tube has its upper end similarly secured to lower sleeve 155.

As shown in Figure 11, platen 43 and facing 44 are mounted on door panel 20 and are dimensioned to extend through opening 150 of cassette frame 151 when the cassette is in operative position and the door is latched closed. When the cassette is in operating position, locating pin 157 of the housing extends through aperture 158 in the upper portion of the frame 151. Tube section 112a engages membrane 28 and is supported or braced by planar platen 43 and its resilient facing 44 in the same manner as shown and described with respect to Figures 3—10. However, the cassette 100 greatly facilitates use of the apparatus, particularly in medical applications, because it may be discarded in its entirety after it has served its purpose, and a new sterile cassette may be inserted into position for use by the same patient or a different patient, without risks of cross contamination and without need to clean and sterilize the used cassette or the pump housing and mechanism.

The ease and speed with which a cassette may be removed and replaced is of course of considerable importance, especially in medical applications where time may be critical. The cassette also insures accurate alignment of the tensioned section 112a of the tube with respect to the rotational axis w of the drive shaft, a critical relationship as previously described in connection with Figures 3—10. Furthermore, the cassette 100 allows precise tensioning or stretching of the linear tube section 112a during manufacture of the cassette. Since the extent of tensioning of the linear tube section affects the internal diameter of that section, reproducibility of flow rates may be assured.

In assembling the cassette of this invention it has been found advantageous to perform the following steps to assure uniform stretching of tube section 112a. The tubing is first connected to sleeves 156 before the sleeves are attached to perimetric frame 151. The frame is mounted on a jig (not shown) utilizing the alignment aperture 158. The jig accommodates two conventional ultrasonic welding horns, and one of the horns is operated to weld one of the sleeves 156 to the frame. A weight capable of exerting a predetermined stretching force is attached to the other end of the tubing and the tubing is freely stretched by the weight. The other attachment sleeve 156, which has been connected to the tubing but has been allowed to float freely with regard to the frame, is then secured to the frame by the second ultrasonic welder. Accurate "inline" measurement of tubing inside and outside diameters is possible by means of laser micrometers, air gauges, or the like. If a deviation is detected then the extent of stretching may be readily adjusted by varying the weight used to produce such stretching. By such a procedure, stretching, tubing size, and pumping action may be accurately controlled. While ultrasonic welding has been found particularly effective, other means of attachment such as cementing, solvent bonding, or mechanical fastening may be used.

Should production operations result in variations in the inside diameters of the tensioned tube sections 112a of the cassettes and not be corrected by stretching adjustment as described above, each cassette may be coded with suitable indicia, colors, or indentations on the frame 151 or elsewhere to indicate the average ID of the tensioned tubular pumping section 112a of that particular cassette, and the microprocessor of the pump mechanism may then be programmed accordingly to correct the pump speed to achieve the required delivery rate. If desired, the pump may be equipped with mechanical or electrooptical transducers for reading such coding automatically.

The frame 151 of the cassette includes a tab portion 159 which projects beyond the door 20 when the door is closed and the cassette is in operative position, thereby providing a clear visual indication that a cassette is in place. In addition, tab portion 159 is easily gripped by a user to facilitate insertion and removal of a cassette.

Depending on its intended use, the system may include safety functions to insure that unintended interruptions or changes in pump operation will not occur or at least will not pass undetected. For such purposes, the opening 150 in the cassette frame, and the tensioned pump section 112a of the tube, are substantially longer than the series of bearing assemblies 29. When the cassette is in place, the lower portion of tube section 112a bridges a pair of guides 160, 161 and extends between the emitter 162 and receiver 163 of an ultrasonic or photoptic bubble detector. Also, an occlusion detector 164 may contact a portion of the tube directly below, or on the discharge side, of the series of rotor bearing pump assemblies 29 to sense increases in back pressure that might be caused by kinking of the outlet section 112c of the tube, obstruction of needle 117, or any other reason. Since bubble detectors and pressure sensors are well known in the art and do not constitute elements of this invention, further discussion is believed unnecessary herein.

The rigid platen 43, resilient facing 44, and elastomeric tube 12 and 112a are all preferably formed of materials that have sufficient transparency to permit a user or operator to view the peristalsis of the tube and the movement of fluid therethrough through the platen. For that purpose, the platen 43 may be formed of glass or any rigid and adequately transparent polymeric material such as polymethyl methacrylate, polymethyl alphachloro acrylate, cyclohexyl methacrylate, and the like. The facing layer 44 and tube 12 and 112a are preferably formed of silicone rubber or polyurethane rubber, but any elastomeric material having similar properties may be used. The elastomeric material of membranes 40

and 40' may also be silicone rubber or polyurethane rubber but, since transparency of the membrane is not necessary, a variety of other elastomeric materials such as neoprene may be utilized.

Claims

1. A linear peristaltic pump apparatus comprising a housing (18); a shaft (33) rotatably supported by said housing; means (24) for rotating said shaft (33); a helix defining a first linear zone of contact; a cassette (100) removably supported by said housing (18) and comprising a rigid frame (151) and a generally straight section (112A) of elastomeric tubing (112) supported thereby; means (157, 158) provided by said housing (18) for orienting said frame (151) with said section (112A) of tubing laying in the same plane as said first zone of contact; and platen means (43) engageable with said section of elastomeric tubing (112) to urge the same into engagement with the opposite side of said first linear zone along a second linear zone of contact parallel with said first zone of contact; characterized by a series of bearing assemblies (29) each having concentric inner and outer bearing members (30, 31); said inner members (30) being eccentrically mounted upon said shaft (33) with the centers of said inner members being arranged to describe a helix about the axis (36) of said shaft (33); an elastomeric membrane (40) extending along and tangentially engaging the outer members (31) of said bearing assemblies (29) along the first linear zone of contact; said frame (115) of said cassette (100) being planar and perimetric, and defining an opening (150); attachment sleeves (154, 155); provided by said frame (151) along opposite edges of said opening (150); said straight section (112A) of elastomeric tubing extending across said opening (150) and having end portions secured to said attachment sleeves (154, 155); said platen means (43) being provided by said housing (18) and extending into said opening (150) to urge said tubing section (112A) against said membrane (40) towards said bearing assemblies (29) when said apparatus is in operation.

2. The apparatus of Claim 1 in which said generally straight section (112A) of elastomeric tubing (112) is supported by said frame (151) in predetermined axially stretched and tensioned condition.

3. The apparatus of Claim 2 in which said cassette (100) is coded to indicate the average inside diameter of said stretched and tensioned section (112A) of tubing (112).

4. The apparatus of Claim 2 in which said opening (150) is generally rectangular and is elongated in a direction parallel to said section (112A) of tubing (112).

5. The apparatus of Claim 1 in which said cassette (100) includes a pair of end sections (112B, 112C) of tubing (112) extending axially from opposite ends of said generally straight section (112A) of tubing (112); and connecting means (117) at the free end of one of said end sections for connection with a patient.

6. The apparatus of Claim 5 in which said cassette (100) includes coupling means (113) at the free end of the other of said end sections for fluid-transmitting coupling with a medical container.

7. The apparatus of Claim 1 in which said section (112A) of elastomeric tubing (112) is transparent.

8. The apparatus of Claim 1 in which said means for orientating said cassette comprises at least one locating pin (157) provided by said housing (18) and at least one aperture (158) provided by said cassette frame (151) for receiving said pin.

9. A disposable cassette for use in a linear peristaltic pumping apparatus, comprising a rigid planar frame (151); characterized by said frame (151) extending about an opening (150); attachment sleeves (154, 155) provided by said frame (151) on opposite edges of said opening (150); and a straight section (112A) of elastomeric tubing (112) extending across said opening (150) and having end portions secured to said attachment sleeves (154, 155).

10. The cassette of Claim 9 in which said section (112A) of elastomeric tubing (112) is stretched and supported in a predetermined state of tension.

11. The cassette of Claim 10 in which said cassette is coded to indicate the average inside diameter of said stretched section (112A) of elastomeric tubing (112).

12. The cassette of Claim 9 or 10 in which said section (112A) of elastomeric tubing (112) is transparent.

13. The cassette of Claim 9 in which said frame (151) is provided with locating means (158) for orientating said cassette (100) in relation to a peristaltic pumping apparatus.

14. The cassette of Claim 9 in which a pair of end sections (112B, 112C) of tubing extend outwardly from said sleeves (154, 155) and communicate with said straight section (112A); one of said end sections (112B, 112C) including connecting means (117) at the free end thereof for fluid-transmitting connection with a patient.

15. The cassette of Claim 14 in which coupling means (113), is provided at the free end of the other of said end sections (112B) for fluid-transmitting coupling with a medical container.

Patentansprüche

1. Lineare Schlauchquetschpumpenvorrichtung mit einem Gehäuse (18), mit einer rotierbar in diesem Gehäuse angeordneten Welle (33), mit Mitteln (24) zum Drehen der Welle (33), mit einer Schraubenlinie, die einen ersten linearen Kontaktbereich begrenzt, mit einer austauschbar in dem Gehäuse (18) angeordneten Kassette (100), die einen starren Rahmen (151) und einen in diesem befestigten im wesentlichen geraden Abschnitt

(112A) eines elastomeren Schlauches (112) aufweist, mit in dem Gehäuse (18) vorgesehenen Mitteln (157, 158) zur Orientierung des Rahmens (151) mit dem Abschnitt (112A) des Schlauches in derselben Ebene wie der erste Kontaktbereich, und mit einer Auflageplatte (43), die mit dem besagten Abschnitt des elastomeren Schlauches (112) in Eingriff bringbar ist, um diesen in einen Eingriff mit der gegenüberliegenden Seite des ersten linearen Kontaktbereichs entlang einem zweiten linearen Kontaktbereich, der parallel zu dem ersten Kontaktbereich verläuft, zu bringen, dadurch gekennzeichnet, daß eine Abfolge von Lageranordnungen (29) mit jeweils konzentrischen inneren und äußeren Lagerelementen (30, 31) vorgesehen ist, wobei die inneren Elemente (30) exzentrisch auf der Welle (33) angeordnet sind, wobei die Mitten der inneren Elemente so angeordnet sind, daß sie eine Schraubenlinie um die Achse (36) der Welle (33) beschreiben, daß eine elastomere Membrane (40) sich entlang den und tangential eingreifend in die äußeren Elemente (31) der Lageranordnungen (29) entlang dem ersten linearen Kontaktbereich erstreckt, daß der Rahmen (115) der Kassette (100) eben und perimetrisch ist sowie eine Öffnung (150) begrenzt, daß Befestigungsbuchsen (154, 155) vorgesehen sind, die an dem Rahmen (151) entlang den gegenüberliegenden Kanten der Öffnung (150) geschaffen sind, daß ein gerader Abschnitt (112A) des elastomeren Schlauches sich über die Öffnung (150) erstreckt und Endbereiche aufweist, die an den Befestigungsbuchsen (154, 155) befestigt sind, daß die Auflageplatte (43) an dem Gehäuse (18) vorgesehen ist und sich in die Öffnung (150) hineinerstreckt, um den Schlauchabschnitt (112A) gegen die Membrane (40) hin zu den Lageranordnungen (29) zu drükken, wenn die Pumpenvorrichtung in Betrieb ist.

2. Pumpenvorrichtung nach Anspruch 1, bei der der im wesentliche gerade Abschnitt (112A) des elastomeren Schlauchs (112) durch den Rahmen (151) in einer vorbestimmten axial gestreckten und vorgespannten Lage gehalten ist.

3. Pumpenvorrichtung nach Anspruch 2, bei der die Kassette (100) kodiert ist, um den durchschnittlichen Innendurchmesser des gestreckten und vorgespannten Abschnitts (112A) des Schlauchs (112) anzuzeigen.

4. Pumpenvorrichtung nach Anspruch 2, bei der die Öffnung (150) im wesentlichen rechteckig und in einer parallel zu dem Abschnitt (112A) des Schlauchs (112) verlaufenden Richtung verlängert ist.

5. Pumpenvorrichtung nach Anspruch 1, bei der die Kassette (100) ein Paar von Endbereichen (112B, 112C) des Schlauchs (112), die sich axial von einander gegenüberliegenden Enden des im wesentlichen geraden Abschnitts (112A) des Schlauchs (112) wegerstrecken, und Verbindungsmittel (117) an dem freien Ende von einem der Endbereiche zur Verbindung mit einem Patienten umfaßt.

6. Pumpenvorrichtung nach Anspruch 5, bei der die Kassette (100) Koppelmittel (113) an dem freien Ende des anderen der besagten Endbereiche zur flüssigkeitsübertragenden Verbindung mit einem medinzinischen Behälter umfaßt.

7. Pumpenvorrichtung nach Anspruch 1, bei der der Abschnitt (112A) des elastomeren Schlauchs (112) transparent ist.

8. Pumpenvorrichtung nach Anspruch 1, bei der die Mittel zur Orientierung der Kassette mindestens einen in dem Gehäuse (18) vorgesehenen Paßstift (157) und mindestens ein in dem Kassettenrahmen (151) vorgesehenes Loch (158) zur Aufnahme des Paßstiftes umfassen.

9. Einwegkassette zur Benutzung in einer linearen Schlauchquetschpumpenvorrichtung mit einem starren ebenen Rahmen (151), dadurch gekennzeichnet, daß der Rahmen (151) sich um eine Öffnung (150) erstreckt, daß in dem Rahmen (151) angeordnete Befestigungsbuchsen (154, 155) an gegenüberliegenden Kanten der Öffnung (150) vorgesehen sind, und daß ein gerader Abschnitt (112A) des elastomeren Schlauchs (112) sich über die Öffnung (150) erstreckt und über Endbereiche verfügt, die an den Befestigungsbuchsen (154, 155) befestigt sind.

10. Kassette nach Anspruch 9, bei der der Abschnitt (112A) des elastomeren Schlauchs (112) gestreckt und in einem vorbestimmten Zustand der Spannung gehalten ist.

11. Kassette nach Anspruch 10, bei der die Kassette kodiert ist, um den durchschnittlichen Innendurchmesser des gestreckten Abschnitts (112A) des elastomeren Schlauchs (112) anzuzeigen.

12. Kassette nach Anspruch 9 oder Anspruch 10, bei der der Abschnitt (112A) des elastomeren Schlauchs (112) transparent ist.

13. Kassette nach Anspruch 9, bei der der Rahmen (151) mit Orientierungsmitteln (158) versehen ist, um die Kassette (100) in Bezug auf eine Schlauchquetschpumpenvorrichtung auszurichten.

14. Kassette nach Anspruch 9, bei der ein Paar von Endbereichen (112B, 112C) des Schlauchs sich auswärts von den Buchsen (154, 155) erstreckt und mit dem geraden Abschnitt (112A) in Verbindung steht, und bei der einer der Endbereiche (112B, 112C) Verbindungsmittel (117) an dem freien Ende von diesem zur flüssigkeitsübertragenden Verbindung mit einem Patienten umfaßt.

15. Kassette nach Anspruch 14, bei der ein Koppelmittel (113) an dem freien Ende des anderen der besagten Endbereiche (112B) zur flüssigkeitsübertragenden Verbindung mit einem medinzinischen Behälter vorgesehen ist.

Revendications

1. Appareil de pompage linéaire péristaltique comprenant un corps (18), un arbre (33) porté par ce corps pour pouvoir tourner, un moyen (24) pour entraîner en rotation cet arbre (33), un hélicoïde définissant une première zone linéaire de contact, une cassette (100) portée de manière amovible par le corps (18) et comprenant un

cadre rigide (151) et un tronçon (112A) rectiligne dans l'ensemble d'un tuyau (112) en élastomère supporté par ce cadre, des moyens (157, 158) procurés par le corps (18) pour orienter le cadre (151) avec le tronçon (112A) du tuyau se trouvant dans le même plan que la première zone de contact, une platine (43) pouvant s'engager avec le tronçon de tuyau en élastomère (112) pour pousser ce dernier en contact avec le côté opposé de la première zone linéaire le long d'une seconde zone linéaire de contact parallèle à la première zone de contact, caractérisé par une série de roulements (29) de palier ayant chacun une bague intérieure et une bague extérieure (30, 31) concentriques, ces bagues intérieures (30) étant montées avec excentration sur l'arbre (33) avec les centres de ces bagues intérieures étant disposées pour décrire une hélice autour de l'axe (36) de l'arbre (33), une membrane (40) en élastomère s'étendant le long des bagues extérieures (31) et s'engageant tangentiellement avec ces bagues extérieures (31) des roulements de palier (29) le long de la première zone linéaire de contact, le cadre (151) de la cassette (100) étant plan et périmétrique et définissant une ouverture (150), des manchons de montage (154, 155) procurés par le cadre (151) sur des bords opposés de l'ouverture (150), le tronçon rectiligne (112A) du tuyau en élastomère s'étendant en travers de l'ouverture (150) et ayant des parties extrêmes fixées auxdits manchons demontage (154, 155), la platine (43) étant définie par le corps (18) et s'étendant dans l'ouverture (150) pour pousser le tronçon de tuyau (112A) contre la membrane (40) en direction des roulements de palier (29) quand l'appareil est en fonctionnement.

2. Appareil selon la revendication 1 dans lequel le tronçon rectiligne dans l'ensemble (112A) de tuyau en élastomère (112) est supporté par le cadre (151) en état prédéterminé d'étirement et de tension en sens axial.

3. Appareil selon la revendication 2 dans lequel la cassette (100) est codée pour indiquer le diamètre intérieur moyen du tronçon étiré et mis en tension (112A) du tuyau (112).

4. Appareil selon la revendication 2 dans lequel l'ouverture (150) est rectangulaire dans l'ensemble et elle est allongée dans une direction parallèle au tronçon (112A) du tuyau (112).

5. Appareil selon la revendication 1 dans lequel la cassette (100) comprend une paire de parties extrêmes (112B, 112C) du tuyau (112) s'étendant en sens axial à partir des extrémités opposées du tronçon rectiligne dans l'ensemble (112A) du tuyau (112) et des moyens de raccordement (117) à l'extrémité libre de l'une des parties extrêmes pour raccordement avec un patient.

6. Appareil selon la revendication 5 dans lequel la cassette (100) comprend des moyens de raccordement (113) à l'extrémité libre de l'autre des parties extrêmes pour un raccordement de transmission de fluide avec un conteneur médical.

7. Appareil selon la revendication 1 dans lequel le tronçon (112A) du tuyau en élastomère (112) est transparent.

8. Appareil selon la revendication 1 dans lequel le moyen pour orienter la cassette comprend au moins une goupille de positionnement (157) procurée par le corps (18) et au moins une ouverture (158) procurée par le cadre (151) pour recevoir ladite goupille.

9. Cassette à jeter pour emploi avec un appareil de pompage péristaltique linéaire comprenant un cadre plan rigide (151), caractérisée par ce cadre (151) qui s'étend autour d'une ouverture (150), des manchons de montage (154, 155) prévus sur ce cadre (151) sur des bords opposés de l'ouverture (150) et un tronçon rectiligne (112A) d'un tuyau en élastomère (112) s'étendant en travers de l'ouverture (150) et ayant des parties extrêmes fixées aux manchons de montage (154, 155).

10. Cassette de la revendication 9 dans laquelle le tronçon (112A) du tuyau (112) en élastomère est étiré et supporté dans un état prédéterminé de tension.

11. Cassette de la revendication 10 dans laquelle cette cassette est codée pour indiquer le diamètre intérieur moyen du tronçon étiré (112A) du tuyau en élastomère (112).

12. Cassette de la revendication 9 ou 10 dans laquelle le tronçon (112A) du tuyau (112) en élastomère est transparent.

13. Cassette de la revendication 9 dans laquelle le cadre (151) est pourvu d'un moyen de positionnement (158) pour l'orientation de cette cassette (100) par rapport à un appareil de pompage péristaltique.

14. Cassette de la revendication 9 dans laquelle une paire de parties extrêmes (112B, 112C) de tuyau s'étendent vers l'extérieur à partir des manchons (154, 155) et communiquent avec le tronçon rectiligne (112A), une des parties extrêmes (112B, 112C) comprenant des moyens de raccordement (117) a son extrémité libre pour un raccordement de transmission de fluide avec un patient.

15. Cassette de la revendication 14 dans laquelle un moyen de raccordement (113) est prévu à l'extrémité libre de l'autre des parties extrêmes (112B) pour un raccordement de transmission de fluide avec un conteneur médical.

FIG. 1

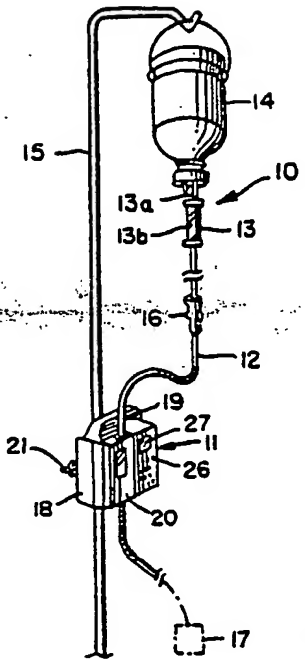

FIG. 2

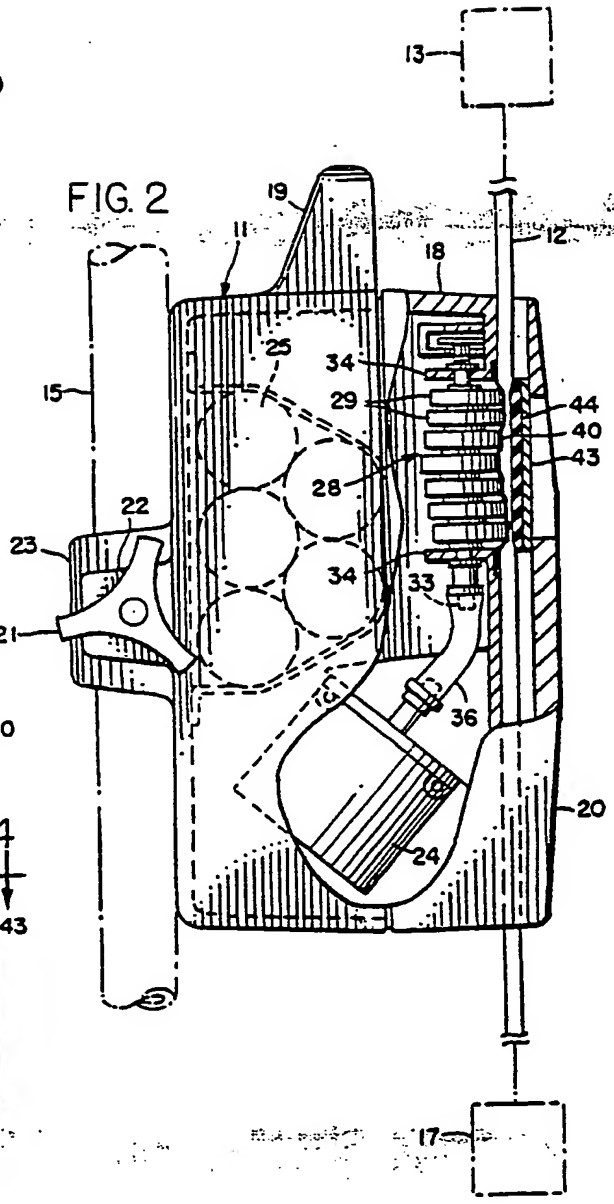

FIG. 3

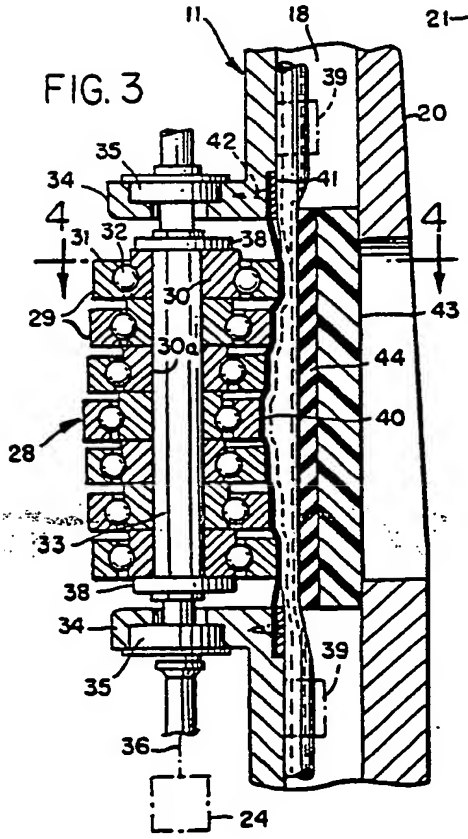

FIG. 4

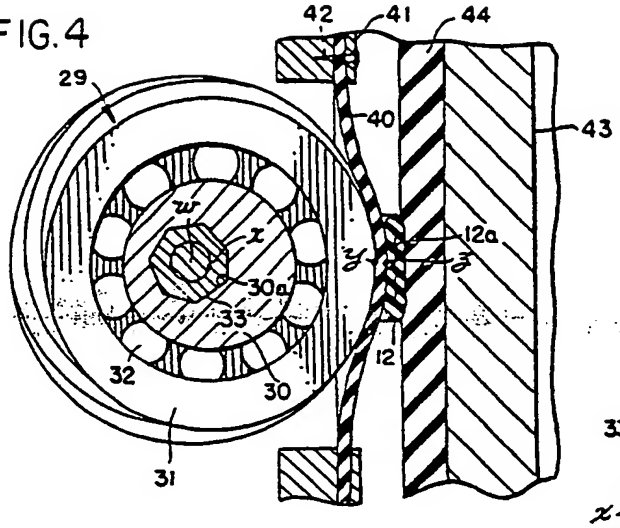

FIG. 5

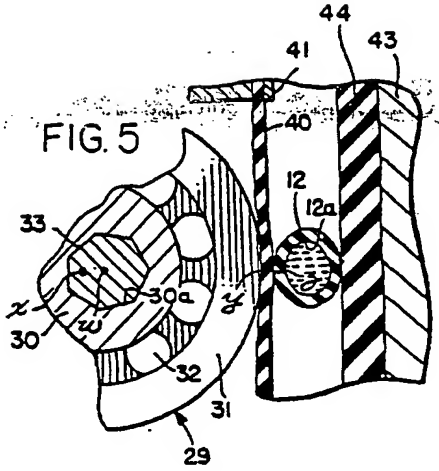

FIG. 10

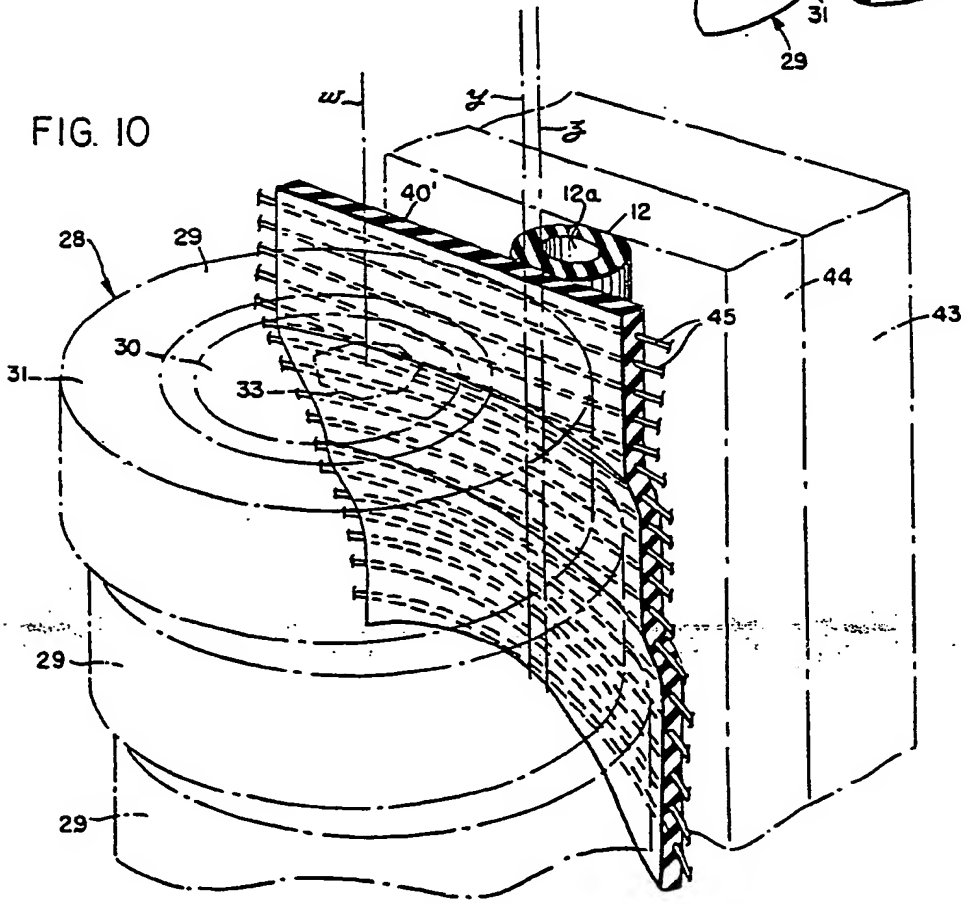

FIG. 6

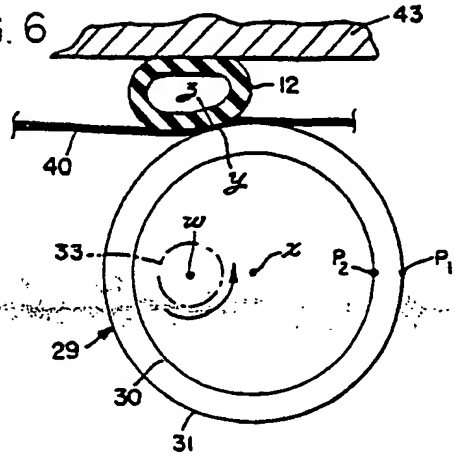

FIG. 7

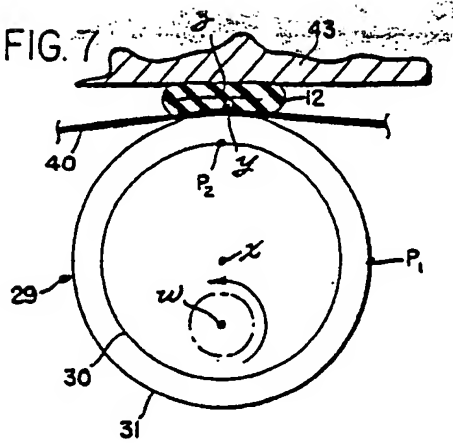

FIG. 8

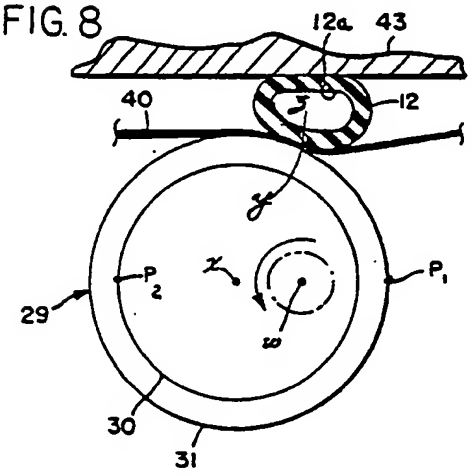

FIG. 9

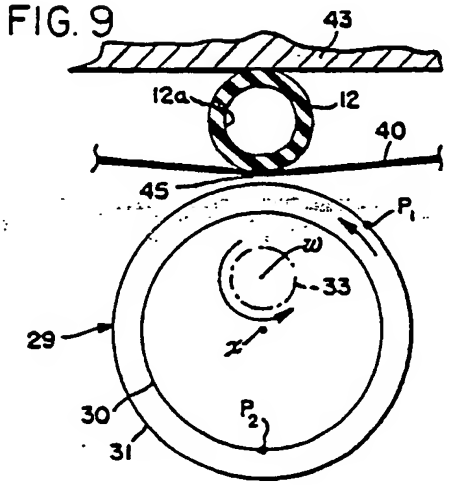

FIG. 11

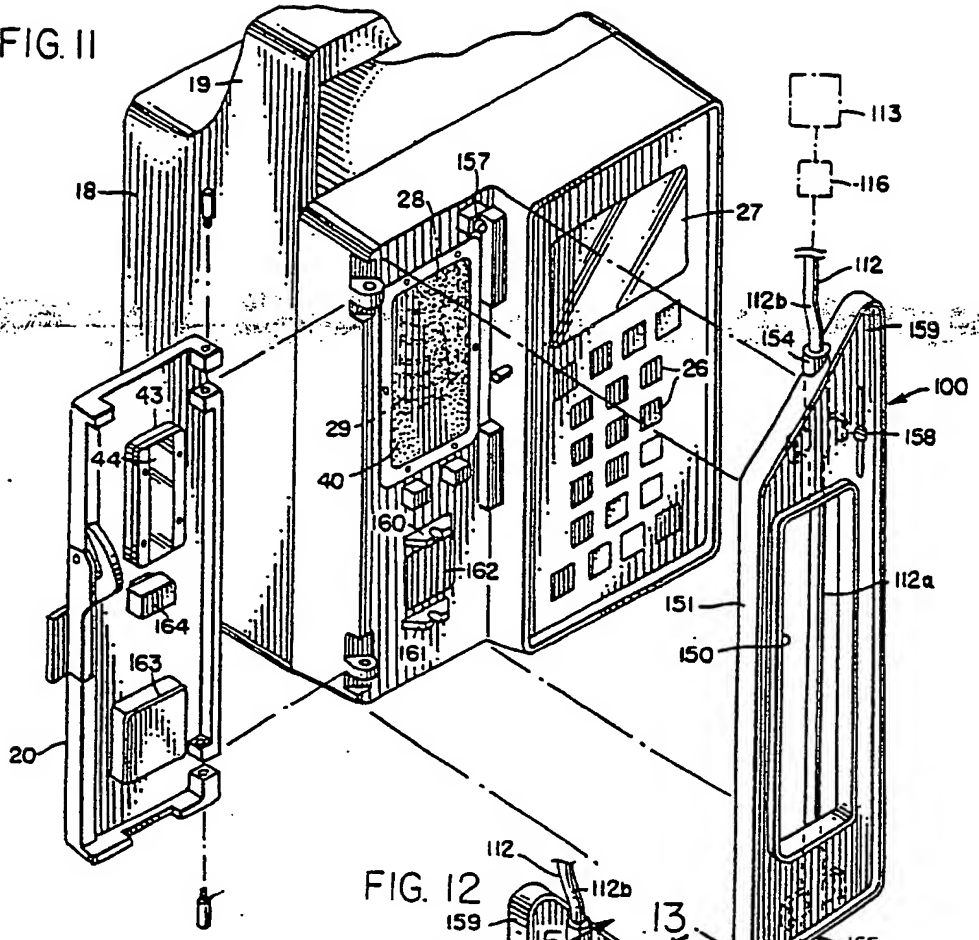

FIG. 12

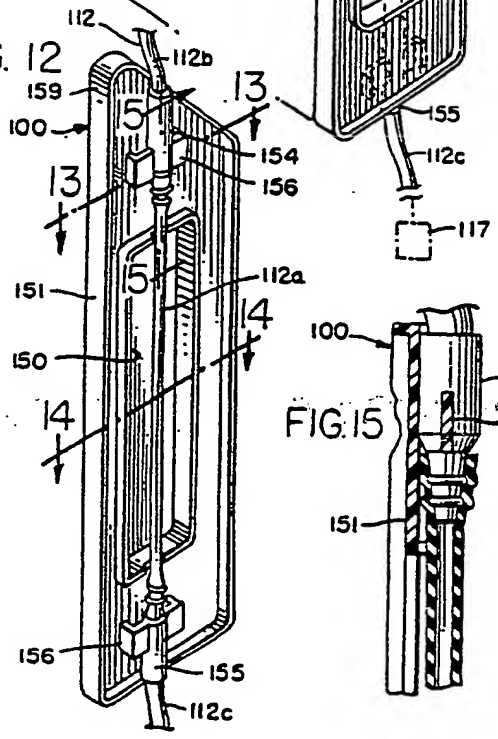

FIG. 13

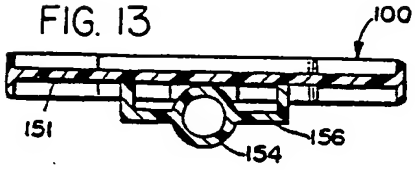

FIG. 14

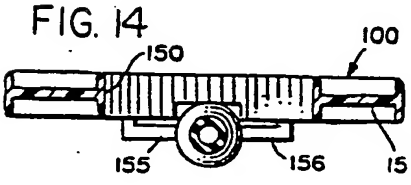

FIG. 15